

(N.E.)  
1) need  
2)

BAKER BOTTS L.L.P.  
30 ROCKEFELLER PLAZA  
NEW YORK, NEW YORK 10112

TO ALL WHOM IT MAY CONCERN:

Be it known that WE, Axel Knauff, Wolfgang Lienke, Klaus Oberndorfer, Klaus Recker and Elmar Schaeffers, citizens of Germany, residing in Műnnerstadt, Obermichelbach, Erlangen, Neumarkt and Nuernberg, respectively, whose post office addresses is are Friedrich-Alberstr. 20, 97702 Műnnerstadt, Germany; Hormersdorfer Str. 20, 90587 Obermichelbach, Germany; Reuthlehenstr. 67, 91056 Erlangen, Germany; Hagenstr. 5, 92318 Neumarkt, Germany; and Frauenholzstr. 3, 90419 Nuernberg, Germany, respectively, have invented an improvement in:

# INJECTION UNIT FOR AN INJECTION-MOLDING MACHINE

of which the following is a

(SUBSTITUTE SPECIFICATION)

## FIELD OF THE INVENTION

[Background of the Invention]

[0001] The present invention relates to an injection unit for an injection-molding machine for processing thermoplastic material, the injection-molding machine having a screw which is guided in a cylinder and the axial movement of which can be initiated by a first motor and the rotary movement of which can be initiated by a second motor, an electrical direct drive being provided as the first motor.

## BACKGROUND OF THE INVENTION

[0002] An injection unit of this type is known from DE 43 44 335 A1. In this unit, polymer is forced out into a mold by a linear movement of a stationary screw. This

operation takes place with a first direct drive. However, material preparation of the polymer has been initiated in each case beforehand by turning of the screw in an assigned cylinder with the aid of a second direct drive.

[0003] Direct drives have the advantage of having very good dynamics, one of the ways in which this is manifested being a very short time span to reach the injection speed. However, direct drives entail relatively high costs. This is because it is not only necessary for the motor to be adapted to the geometry of the machine but also to produce a very high torque at relatively low rotational speeds to provide the required injection speed with the desired injection pressure.

[0004] In the case of direct drives, both the injection motor and the metering motor have to supply a relatively great torque, which is derived, inter alia, from the injection pressure. The second motor, i.e. the metering motor, only moves, however, at rotational speeds which are significantly below the operationally required rotational speed of the injection motor. For example, one possible configuration is designed in such a way that the injection motor has to produce a torque of 1000 Nm at a maximum rotational speed of 1000 rpm, whereas the metering motor has to provide a torque of 1000 Nm for a rotational speed of below 300 rpm.

[0005] In commercially available machines, the two movements are transmitted by indirect drives, using belts or gear mechanisms. The adaptation of the motor torque and motor speed to the requirements of the injection unit then takes place by the respective transmission ratio. In this case, the dynamics for automatic controlling operations are less, however, than in the case of direct drives, but use of standard drives can be made possible by the design of the gear mechanisms.

### SUMMARY OF THE INVENTION

[0006] The object of the invention is to provide an injection unit of the type described above in which optimum conditions with respect to performance and cost-effectiveness are achieved for the overall arrangement.

[0007] The inventors have found that the dynamic requirements in the case of injection units of the type described above are indeed very high for the actual injection operation but not so high for the metering operation, the stated object can be achieved by only the second motor being connected to the screw via a gear mechanism, in such a way that the rotational speed of the second motor can be reduced to a lower speed of the screw, adapted to the material-preparing process.

[0008] A first advantageous design of the invention is characterized in that the gear mechanism can be blocked during the operation of injecting the thermoplastic material. This prevents the metering motor from having to supply a torque during injection.

[0009] In a technically extremely simple form, this block may be provided as a non-return valve.

[0010] An extremely low-cost configuration is obtained by the fact that a belt-pulley gear is provided as the gear mechanism.

[0011] The fact that the first motor rotatably moves a spindle, which is connected to the screw, via a displaceably secured spindle nut allows a rotating motor to be used as a direct drive for producing the axial movement in this respect. Consequently, unlike in the case of using purely linear drives, it is possible to fall back on standard components.

### BRIEF DESCRIPTION OF THE DRAWING

[0012] An exemplary embodiment of the invention is explained in more detail below in conjunction with the appended drawing. The single figure of which illustrates the arrangement of the invention in simplified form.

[0013] The arrangement of the invention, as shown in the drawing, includes a screw SCH, which is mounted to be axially and rotationally movable in a screw cylinder SZ. The free end of the screw cylinder SZ, facing the actual mold parts of the injection-molding machine, is shown in cut-away section. Similarly, feeding elements for pelletized polymer material, for example, into the interior of the screw cylinder SZ are likewise not shown for the sake of overall clarity. The screw SCH is firmly connected to a spindle SP, on which there is mounted a spindle nut SM. The spindle nut is set in to rotation by a first motor, i.e. an injection motor EM, and secured against axial displacement to the motor. In such rotation, with the spindle secured against displacement, axial movement of the screw indicated by a double-headed arrow is initiated, as required for forcing prepared thermoplastic material out of the screw cylinder SZ into the mold, i.e. for the injection operation.

[0014] The spindle SP has, furthermore, on its free end a belt pulley RS1, which is connected via a belt R to a second motor, metering motor DM. When metering motor DM is set in rotation, reduced-speed rotation of the spindle SP and consequently of the screw SCH occurs. This brings about a thorough mixing of the polymer pellets and, at the assumed ambient temperatures, the thermoplastic material is prepared for injection, i.e. metered. Since rotation of the spindle SP with the spindle nut SM unmoved would cause axial movement of the screw SCH and of the spindle SP, this movement countered by an offsetting rotational movement of the injection motor EM. This action ultimately

ensures that the prepared thermoplastic material is made available for injection, ready for the production process, only at a desired system pressure in the screw cylinder SZ.

[0015] The metering motor DM can be effectively disconnected from spindle SP during the injection operation, during which only the injection motor EM is active, by blocking the gear mechanism comprising the belt R and belt pulleys RS1 and RS2. Moreover, as contrasted with the prior art discussed above, the metering motor DM is also completely protected by the belt gear mechanism from axial forces, which would otherwise require expensive axial bearings for absorbing the forces. The metering motor DM may be designed as a built-on motor and run with a high rotational speed and a correspondingly great transmission ratio. If, as in the example discussed above, a torque of 1000 Nm is to be produced at a rotational speed of 300 rpm, a motor with a torque of 100 Nm and a rotational speed of 3000 rpm can be used if there is a transmission ratio of 10 : 1.

[0016] Consequently, according to the invention, an expensive direct drive is used only where the high dynamics which can be achieved with it are actually required. This leads to a decisive cost advantage over the prior art. If an asynchronous motor is used as the metering motor DM, the costs can be further reduced considerably.

[0017] A further important aspect of injection-molding machines is the overall length of the installation. The direct drives according to the prior art are arranged one behind the other and therefore contribute to the total length. In the case of the present invention, in which the second motor, i.e. the metering motor DM, is realized by an indirect drive, it can be mounted, for example, underneath the unit, thereby reducing the total overall length significantly.